Specialization
Poliovirus and rhinovirus have specialized to attack primarily human beings, but they use two different approaches. Poliovirus, which is found in three similar forms, is designed to attack a given person only once. It makes its offspring and then is off to the next person. In most cases, poliovirus causes a simple flu-like disease as it attacks cells in the digestive system. This infection is rapidly cleared up by the immune system. But in about 1 in 100 cases, the virus spreads to the nerve cells that control muscle motion, causing paralysis – poliomyelitis – as the nerve cells are infected.

Rhinovirus, on the other hand, is found in many different forms that attack a given person many times during their life. Each time you get a cold, a different form of rhinovirus (or occasionally, a different type of virus) is attacking. Your body learns how to fight it off, but you are still susceptible to the next form. On average, a person will have a new cold once every two years, so most of us are quite familiar with the symptoms of rhinovirus infection in our nose and respiratory tract. Because they are so simple, picornaviruses can be very stable. Rhinovirus can last for days on your hands and still be infectious. And because the virus is shed from infected people all through the period with symptoms and even for days after, it spreads effectively through contact from person to person.

Vaccines
Antibodies are our major defense against these small, efficient viruses. Vaccines prime the immune system with antibodies, making it ready to fight an infection. In the case of poliovirus, there are two types of vaccines. One is a killed version of the virus, which is slowly killed with formaldehyde over the course of several days so that it is inactivated, but still keeps its proper shape. The second is a weakened, but still live, strain of the virus that has been artificially bred to stimulate the immune system without causing disease. The immune system responds by making antibodies to fight these weakened viruses, leaving it ready to fight the real thing when it comes along.

The polio vaccines are one of the triumphs of modern medicine, but many people would say that the lack of a cure for the common cold is one of the great failings. The difficulty of creating a vaccine for the common cold lies in the diversity of rhinovirus. Over one hundred types of rhinovirus have been discovered as they strike people around the world, and new strains appear continually. Rhinovirus is a moving target that is not effectively combated with a single vaccine. Antiviral drugs, however, are a possible solution.

Picornavirus Structure
Many viruses, including the picornaviruses and bacteriophage phiX174 (discussed in an earlier Molecule of the Month), are icosahedral in shape. They are composed of 60 identical pieces that form a perfectly symmetrical shell, termed a capsid, around the viral genome. In the case of poliovirus and rhinovirus, the shell is composed of 60 copies of four different proteins (colored yellow, orange, red, and magenta on rhinovirus here, PDB entry 4rhv), for a total of 240 protein chains in all. Notice that the fourth chain, colored magenta, can only be seen on the inside surface of the capsid. These proteins are carefully designed to be stable, but not too stable. They must be fairly sturdy to allow the virus to pass from host to host through the hostile environment. But at the same time, they must be able to fall apart when they enter the cell, releasing the RNA inside. A carefully orchestrated
POLIOVIRUS AND RHINOVIRUS

Antibodies Protection

Antibodies bind to the surface of picornaviruses and stop them from attacking cells. In the left picture, rhinovirus is bound to a receptor protein on the cell surface, shown in blue (from PDB entry 1dgi). Notice that the receptor protein is gripped within a groove that encircles the five-fold symmetrical arrangement of proteins shown in yellow (known as the canyon in the picornavirus literature). Antibodies bind to the surface of rhinovirus and poliovirus in this same position and block their attachment to the surfaces of cells. The right picture shows fragments of antibodies (in light blue) bound to rhinovirus (from PDB entry 1rvf). The intact antibodies are much larger than the small fragments seen here, so seven to ten antibodies are enough to form a bulky barrier on each virus to block attachment and infection.

Exploring the Structure

Many structures of rhinovirus with antiviral drugs are available at the PDB, including the drug pleconaril, currently in clinical testing, shown here (PDB entry 1c8m). In this illustration, the drug is shown in spheres, and only four protein chains are shown, instead of the entire capsid. The inside of the virus is towards the bottom of the figure and the deep groove where the cellular receptor and antibodies bind can be seen on the upper side, shown with an arrow. Most drugs act by blocking protein binding sites or destabilizing a key interaction. These drugs, on the other hand, may act differently. They actually stabilize the virus structure so that it cannot release its cargo of RNA. The drugs bind in a little pocket under the deep groove that grabs onto the cellular receptor. Normally, the binding of virus to receptor shifts the structure of the virus, ultimately allowing the virus to release RNA. The drug, however, glued the virus shut.

About the Text

This feature is part of the RCSB PDB’s Molecule of the Month series that presents short accounts on selected molecules from the Protein Data Bank. Each installment includes an introduction to the structure and function of the molecule, a discussion of the relevance of the molecule to human health and welfare, and suggestions for how visitors might view representative structures themselves.

This entry was written and illustrated by David S. Goodsell (RCSB PDB and the Scripps Research Institute) in August 2001.

Structures mentioned in this feature:


1c8m (Chakravarty, S., Bator, C.M., Pevear, D.C., Diana, G.D., Rossmann, M.G. THE Refined STRUCTURE OF A PICORNAVIRUS INHIBITOR CURRENTLY IN CLINICAL TRIALS, WHEN COMPLEXED WITH HUMAN RHINOVIRUS 16 to be published)